ARCADIS
Infrastructure, environment, facilities

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Volume II:
Field Sampling Plan

HPI Products, Inc.
St. Joseph, Missouri

19 May 2008

PREPARED FOR:

HPI Products, Inc.
St. Joseph, Missouri 64501

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Our Ref.:
KC001543.0001

Date:
19 May 2008

LIST OF MODIFICATIONS/DELETIONS/ADDITIONS

REVISION #	DATE	SECTION	PAGE	SUMMARY OF CHANGE
0		All	All	
1	5/19/08	3.2.1	p. 5-6	Revision resulted from USEPA comment letter dated May 5, 2008

1.0 Introduction

ARCADIS U.S., Inc. (ARCADIS) was retained to prepare the Field Sampling Plan (FSP) portion of the consolidated Site Characterization Work Plan. This FSP was prepared to provide field personnel with detailed instructions and procedures regarding activities to be performed during the Site Characterizations at the HPI facilities located in St. Joseph, Missouri. This FSP also presents procedures to document the field activities required during the Site Characterization.

This plan was prepared for use by the field sampling team during data acquisition to produce accurate, comparable, and reproducible data for reduction and evaluation. The site background and overall sampling and analysis program are discussed in the consolidated Site Characterization Work Plan.

2.0 Project Preparation and Mobilization

Initial project coordination, subcontractor coordination, and utility clearance activities will be conducted prior to initiating the field sampling activities. These pre-mobilization activities are discussed in the following subsections.

2.1 Initial Coordination

The U.S. Environmental Protection Agency (USEPA) Region VII and the Missouri Department of Natural Resources (MDNR) will be notified at least 30 days before the start of any field work.

2.2 Subcontractor Coordination and Mobilization

The subcontractors will be selected and contracts will be negotiated in advance of beginning the field activities. This will include coordination with the potential direct-push contractor, driller, analytical laboratory, geotechnical laboratory, surveyor, and private utility locator.

2.3 Underground Utilities

Prior to mobilization, all underground utility lines, other underground structures, and aboveground power lines will be clearly marked. A utility locate will be completed on-site with HPI personnel and a private utility locator to identify private utilities that will not be located by the Missouri One-Call locator(s). Facility personnel will be responsible for making certain the underground utilities and structures are located and marked. A private utility locator may be hired to identify private utilities that cannot be completely located by the site personnel. Additionally, utilities that must be uncovered in special high-risk areas may be excavated using air-knifing techniques to expose the utilities without damaging the line. Upon arrival at the facility, the site manager will check the proposed probing, drilling, and sampling locations for marked underground utilities, other underground structures and aboveground pipe racks or power lines. A Utilities and Structures Checklist(s) (Appendix A) will be completed by the site manager for each area to be sampled prior to commencement of field activities. A copy of the completed checklist will be retained in the ARCADIS project file.

2.4 Site Reconnaissance

Prior to startup of sampling activities in a particular area, field personnel will conduct a brief site reconnaissance to determine if any problems with the drilling or sampling locations will be encountered. The sampling locations will be sketched on a Site Location Form (Appendix A), if an appropriate map of the area is not available. In addition, at the start of field activities at each sampling area, the field personnel will notify facility personnel of the work schedule, and sampling and drilling locations.

2.5 Field Operations Contingency Plans

If during the field program, any unforeseen problems or conditions are encountered, such as, extreme precipitation events, site emergencies that require evacuation of field personnel, changes in site conditions, security problems, loss of power or communications, or community relations problems, the following actions will be taken as deemed appropriate by the ARCADIS Project Manager:

- For any problem or condition encountered by the field team, the team personnel will immediately notify facility personnel and/or the ARCADIS project manager for direction or approval of corrective action.
- If the problem or condition requires downtime at the site and re-evaluation of any site conditions, assumptions made about the site conditions, or plans prepared for the site, the field team will contact the ARCADIS project manager and facility personnel for consultation.
- If after consultation, the problem or condition continues, the field program will remain on hold until direction from the facility representative or ARCADIS project manager.
- Any time these contingency procedures are implemented, the following will be documented in the daily log of activities:
  - Problem or condition encountered
  - Personnel involved
  - Management personnel contacted
  - Corrective actions taken, if any
  - Dates and times involved.

2.6 On-Site ARCADIS Representative

A qualified ARCADIS representative will be on-site during all probing, drilling, surveying, and sample collection activities. The ARCADIS representative will have in their possession a copy of the Site Characterization Work Plan (Volume I) and associated FSP (Volume II), Quality Assurance Project Plan (QAPP) (Volume III), and Health and Safety Plan (HASP) (Volume IV). The ARCADIS representative will also have on-site that equipment, tools, references, and documentation necessary to collect, describe, and document the information generated from the field activities.

2.7 Contractor Compliance and Permitting

The subcontractors selected for this project shall comply with all local, state, and federal health and safety regulations and requirements. The contractors are responsible, per ARCADIS contractual agreements, for securing and/or complying with permits required by state or local authorities. The selected contractors will have the necessary license(s) or certifications required to perform such work in Missouri.

2.8 Adherence to Technical Specifications

All work performed by ARCADIS or a subcontractor, whether it be drilling, sampling, surveying, equipment decontamination or other related activities, will be in accordance with the procedures described this FSP, and properly and completely documented by the on-site ARCADIS representative on forms provided in Attachment 1.

3.0 Field Investigation Methods

A detailed discussion of the field procedures that will be employed to complete the Site Characterization tasks is provided below.

3.1 Lithologic Logging

The lithology of the soil and bedrock samples collected during the site characterization will be described through visual observations of the soil/bedrock cores using the Unified Soil Classification System (USCS) and/or the ASTM Standard D 2488 for Description and Identification of Soils. The Boring/Well Construction Log (Appendix A) will be used to record lithologic logging observations. The following logging sequence will be used for the description of unconsolidated materials:

- Describe major soil type and percentage;
- Describe composition of the soil;
- Describe the moisture, texture and color of the soil;
- Document other geologic observations such as bedding characteristics, structure and orientation and primary and secondary permeability/porosity (if possible);
- Document observations on drilling progress including sample interval loss and recovery.

3.2 Direct Push Borings and Sample Collection

Direct-push soil sampling consists of hydraulically pushing or driving a small diameter, hollow steel rod to a target depth and collecting a soil or groundwater sample. The equipment necessary for the collection of samples using the direct push technique is mounted on a regular van or truck for ease of mobility. The steel probe rods, 4 feet (ft) to 5 ft in length, are threaded for easy connection and have tight seals to provide a continuous length of rod. The rods are hydraulically driven or hammered to target depths. The steel rods can be driven to depths of up 150 ft through unconsolidated sediments.

3.2.1 Soil Sample Collection

The following procedures will be used during the collection of surficial, subsurface, and sub-slab soil samples from direct push borings.

1. Record borehole location and intended sample depth intervals on an ARCADIS Soil Boring/Well Construction Log (Appendix A).
2. For sub-slab soil borings or perimeter borings completed through pavement, a coring machine may be used to core through the floor or pavement prior to initiating boring.
3. Line the 4 to 5 ft steel soil sampler core barrel with an acetate or polyethylene liner and attach sampler to end of steel rods.
4. Hydraulically push or drive the soil sampler and rods to the intended depth.
5. Open the core barrel, and disassemble revealing the soil core sample within the liner. Mark the depths, top, and bottom of the liner.
6. For health and safety purposes, the cores recovered in each core barrel will be screened immediately in the field using PID or FID screening equipment to document evidence of subsurface impacts and the levels of photoionizable organic vapors present.
7. The portion of each sample that will be submitted to the laboratory will be collected with an EnCore sampling device or similar for VOCs and additional sample for SVOCs, pesticides, herbicides, and metals will packed into laboratory provided sample containers, labeled, and placed on ice.
8. The remaining soil sample will be extracted from the liners and used to collect organic vapor headspace readings and for logging purposes.
9. To collect volatile organic headspace readings, soil samples will be placed in a sealed plastic bag approximately two-thirds full allowing for approximately 30 percent headspace. The bag will be placed in a dry area, which is as close to room temperature (70° F) as practical. After a minimum of 10 minutes, a PID will be used to measure the vapors that accumulate in the bag due to off-gassing from the sample. The measurement will be recorded on the Soil Boring/Well Construction Log.
10. The soil samples will be described in the field by a qualified and experienced ARCADIS representative. The lithology of the soil will be described through visual observations of the soil core using USCS nomenclature.
11. Place all soil cuttings in drums or roll-off box.
12. All downhole sampling equipment will be properly decontaminated prior to subsequent use in consecutive sample collection. Decontamination procedures are described in Section 3.9.

3.2.2 Groundwater Sample Collection

The following procedures will be used during the collection of groundwater samples from direct push borings.

1. Record sampling location and intended sample depth intervals on an ARCADIS Groundwater Sampling Form (Appendix A).

2. Drive a stainless steel mill slotted rod or retractable screen attached to the bottom of the hollow steel rods to the target depth beneath the groundwater table.

3. If using the retractable screen, the rods will be raised approximately 2 to 4 ft to drop the screen into the aquifer, thus allowing collection of groundwater samples at the target depth.

4. New, clean polyethylene or Tygon tubing (1/4-inch diameter) will be inserted into the hollow rods to allow for collection of grab groundwater samples with a peristaltic pump or dedicated tubing with a check valve assembly.

5. Approximately three direct push borehole volumes of water will be purged prior to sample collection. The following equation will be used to determine the boring volume of standing water:

$$\mathbf{V = 7.48\, \pi\, r^2 h}$$

where, V = Volume of standing water (gallons)

7.48 = gallons per ft^3

π (pi) = 3.14

r = Radius of boring (ft)

h = Height of standing water (ft), total depth minus depth to water

6. The groundwater samples will be collected directly into laboratory-prepared, preserved sample bottles and placed directly on ice. The sample bottles will be filled in the following order: VOCs first, then any other parameters (i.e. SVOCs, herbicides and pesticides, metals, and other inorganic parameters, in that order).

7. If collecting groundwater samples from multiple depths at the same location, separate borings will be completed to prevent cross-contamination.

8. All downhole sampling equipment will be properly decontaminated prior to subsequent use in consecutive sample collection. Decontamination procedures are described in Section 3.9.

3.2.3 Membrane Interface Probe Borings

The Membrane Interface Probe (MIP) is a type of direct push tool, advanced by a standard direct push rig that logs both total VOC concentrations and soil conductivity with depth. The following procedures will be used during the completion of direct push borings using the MIP.

1. Record borehole location on an ARCADIS Soil Boring/Well Construction Log (Appendix A).

2. Hydraulically push the MIP and rods to intended target depth. Since the MIP probe cannot be hydraulically hammered, the MIP probe cannot be driven as deep as conventional Geoprobe™ borings.

3. Pull back MIP and rods at a consistent rate determined by contractor to log the borehole.

3.2.4 Temporary Piezometer Installation

Temporary shallow piezometers will be installed in selected Geoprobe™ soil or groundwater borings. The temporary shallow piezometer installation procedures are discussed below.

1. After the collection of soil and/or groundwater samples from the selected Geoprobe™ borings, a temporary piezometer will be installed in the borehole to a depth of approximately 25 to 30 ft bgs and will be constructed with 10 ft of ¾-inch to 1¼ -inch diameter PVC screen and riser.

2. The natural formation will be allowed to collapse around the piezometers. Sand filter pack will be introduced up to 2 ft above the screen if the native material does not collapse around the screen.

3. The annular space around the upper 10 ft of the piezometer will be filled with granular bentonite and then hydrated to prevent possible interference from surface water leakage.

4. Since the piezometer is considered temporary, a concrete surface pad will not be installed.

5. Each piezometer will be closed with a PVC cap.

3.2.5 Temporary Piezometer Fluid Gauging

Static fluid levels in each temporary piezometer will be gauged using an electronic water-level indicator. Fluid-level measurements will be documented on ARCADIS Well Gauging Logs.

The following procedures will be implemented when collecting fluid-level measurements:

1. Remove the piezometer cap and document the general condition of the piezometer.

2. Measure static fluid-level elevation using an electronic water-level indicator from fixed reference point (generally the north side of the top of the PVC casing).

3. The measurements will be repeated until two consecutive measurements are obtained that are within 0.01 ft.

Fluid-level measurements will be referenced to a surveyed elevation point located on the top of the piezometer casing. All fluid-level measurements will be taken at least two times to check the reproducibility of the measurement data. If it is found that the measurement cannot be reproduced, a second set of data will be collected. Fluid levels will be collected until the data can be reproduced. This measurement validation process ensures the accuracy of the fluid-level data.

Equipment used to measure the fluid level will be properly decontaminated before each use and between each well using the procedures described in Section 3.8.

3.2.6 Direct Push Boring Abandonment

Direct push soil borings installed at the site will be abandoned by allowing the saturated portion of the formation (i.e., unconsolidated sands and gravel) to collapse back into the 2-inch diameter borehole as the Geoprobe™ rods are retracted. The upper 10 to 20 ft of the borehole will be plugged with granular bentonite and hydrated with water.

3.2.7 Temporary Piezometer Abandonment

The well casing and screen materials from the temporary piezometers will be pulled out of the ground to allow the saturated formation (i.e., unconsolidated sands and gravel) to collapse back into the borehole as the small diameter PVC piezometer piping is retracted. The upper 10 to 20 ft of the borehole will be plugged with granular bentonite and hydrated with water.

3.3 Drilling and Monitoring Well Installation

This section presents the procedures to be utilized for drilling if it is required during Site Characterization.

3.3.1 Drilling Method Selection

Based on the type of sediments previously encountered at the facility, soil borings drilled for installation of shallow and intermediate monitoring wells will be installed using the hollow stem auger method (ASTM 1452) and deep wells will be installed using the mud rotary or rotosonic drilling methods.

3.3.2 Shallow and Intermediate Soil Borings and Monitoring Wells

3.3.2.1 Hollow Stem Auger Drilling

Shallow and intermediate boreholes completed as monitoring wells will be drilled using hollow stem auger flights with 8.25-inch outside diameter and at least a 4.25-inch inside diameter. Soil samples collected from the boreholes will be collected continuously using a continuous core sampler or split-spoon sampler (ASTM 1586 and 1587) depending upon percent recovery realized using the continuous core sampler. For couplet and triplet wells, only the deepest borehole of the set will be continuously sampled. All drilling and downhole equipment will be steam-cleaned at a designated decontamination staging area prior to use at each borehole location.

The following procedures will be used during the drilling of all shallow and deep soil borings. The procedure provides information on sampling, data recording, and equipment decontamination techniques, as follows.

1. Record borehole location and intended sample depth intervals (if appropriate) on an ARCADIS Soil Boring/Well Construction Log.

2. The core sampler is advanced in the borehole ahead of the augers and retrieved through the hollow-stem portion of the augers after each 5-ft is drilled. The core barrel is then disassembled revealing the soil core sample. If continuous core sampling is not possible due to the character of the subsurface sediment types encountered, samples will be collected every 5-ft using a standard split-spoon sampler. In this method of sampling, the split spoon is attached to the drill rods, inserted within the hollow-stem auger, and driven into the unconsolidated sediments using a standard 140-pound drop hammer and rig-driven cathead. Blow counts are recorded for each 6-inch penetration of the split spoon. Each split spoon will be driven a total of 18-inches.

3. The cores recovered in each core barrel, or split spoon, will be screened immediately in the field using PID or FID screening equipment to document evidence of contamination and the levels of photoionizable organic vapors present.

4. The portion of each sample that will be submitted to the laboratory will be collected with an EnCore sampling device or similar for VOCs and additional sample for SVOCs, pesticides, herbicides, and metals will packed into laboratory provided sample containers, labeled, and placed on ice.

5. The remainder of the soil sample will be collected for headspace gas analysis during drilling. Soil samples will be placed in a sealed plastic bag approximately two-thirds full allowing for approximately 30 percent headspace. The bag will be placed in a dry area, which is as close to room temperature (70° F) as practical. After a minimum of 10 minutes, a PID meter will be used to measure the vapors that accumulate in the bag due to off-gassing from the sample. The measurement will be recorded on the Soil Boring/Well Construction Log. The PID will be calibrated to benzene using isobutylene gas on each day prior to field activities and recorded on the Daily Log form.

6. The core samples will be described in the field by a qualified and experienced ARCADIS representative. The lithology of the soil will be described through visual observations of the soil core using USCS nomenclature.

7. Containerize all soil cuttings.

8. All downhole sampling equipment will be properly decontaminated prior to subsequent use in consecutive sample collection. Decontamination procedures are described in Section 3.9.

3.3.2.2 Geotechnical Sample Collection

The following procedures will be used to collect soil samples (if any) for geotechnical analysis.

1. Record the soil sample location, depth, date and time of collection, sample identification, name of sampling personnel, and type of drilling and sampling equipment on the Boring/Well Construction Log (Appendix A).

2. Clean and assemble the continuous or split-spoon sampler. The sampler will be fitted with 6-inch long California (brass) rings or equivalent sampler liners, so that soil samples can be retrieved with minimum disturbance for geotechnical analyses. A Shelby Tube may be used in place of the 6-inch sample rings.

3. Lower the sampler through the drill stem to the desired sampling depth. If using a split-spoon sampler, drive the sampler with a standard 140-pound hammer free-falling 30-inches in accordance with ASTM Method D1586. Record the number of blows per foot required to drive the split spoon.

4. After the continuous core barrel or split-spoon sampler is retrieved and opened, mark with indelible ink the depths of the sample at the top and bottom of each brass ring. Using a stainless steel spatula or knife, cut the soil sample between the brass rings. Using plastic caps, cap each end of each ring. Label each ring with the appropriate sample designation.

5. The geotechnical samples do not have to be placed on ice or chilled.

3.3.2.3 Monitoring Well Construction

This section presents monitoring well construction and details for monitoring wells that may be installed at the Site. Monitoring well construction details will be documented on ARCADIS Soil Boring/Well Construction Logs. No water will be introduced during monitoring well construction unless the borehole conditions require stabilization. If required, the water will be obtained from an approved source of potable water.

1. The screened interval of the shallow monitoring wells is anticipated to be 10 to 15 ft of factory-milled 10 slot, 2-inch O.D., schedule 40 PVC screen, placed in the bottom of each well. The well screen attached to threaded, flush joint, 2-inch O.D., schedule 40 PVC casing will be inserted in the borehole through the minimum 6.25-inch O.D. hollow-stem auger.

2. The screened interval of the intermediate monitoring wells is anticipated to be 10 to 15 ft of factory-milled 10 slot, 2-inch O.D., schedule 40 PVC screen, placed in the bottom of each well. Centralizers may be used to ensure that the screen is placed in the center of the boring, and that the sand pack is placed evenly around all sides of the screen via a tremie pipe. The well screen attached to threaded, flush joint, 2-inch O.D., schedule 40 PVC casing with centralizers will be inserted in the borehole through the minimum 6.25-inch O.D. hollow-stem auger.

3. Casing will be added to the well and brought from the top of the screened interval to a height of 3 ft above ground level for completion. In high traffic areas and in building interiors, flush-mounted well completions will be used.

4. The annular space between the well and the borehole wall will be backfilled with a clean, graded, size 20 to 40 silica sand pack that will extend from the bottom of the borehole to a minimum of 2 ft above the top of the screened interval. The sand pack will be placed by tremie pipe from the bottom of the borehole through the hollow-stem augers to ensure complete placement around the well screen. The hollow stem auger will be retrieved as the sand pack is put in place.

5. Approximately 1 ft of very fine sand may be placed above the filter pack to prevent the migration of the bentonite slurry into the well screen.

6. A minimum thickness of 2 ft of bentonite pellets or chips will be placed on top of the filter pack as a seal. If the seal is within the unsaturated zone at the time of

installation, the bentonite will be saturated with potable water and allowed to hydrate. Hydration time will conform to the manufacturer's recommendations before further work on the well is performed. If the well is being set within flowing sands and a layer of very fine sand was installed, a 5 ft thick layer of bentonite slurry mixed thicker (using less water) than manufacturers specifications may be installed in place of the bentonite chips to ensure a seal is installed between the filter pack and the grout.

7. The annular space from the top of the bentonite seal to within 1 foot beneath the frost line will be filled with a cement and bentonite slurry containing high solids mixed to the manufacturer's specifications. The bentonite slurry will be placed with a tremie pipe from the bottom of the annular area to be grouted to ensure proper placement of the slurry.

8. The remaining annular space near land surface will be filled with concrete. Wells will be completed as either flush grade or above grade using a protective steel cover. A concrete apron will be installed around the cover. The apron will be a minimum of 2 ft by 2 ft and 4-inches in thickness, and shall be sloped to promote drainage away from the well. The wells also will be equipped with locking caps.

9. At selected above grade completion locations, steel guard posts or protective barriers will be installed around the wells in a manner designed to prevent vehicles from accidentally damaging the well.

3.3.3 Deeper Monitoring Well Drilling Techniques

The following methodologies will be used for installing any intermediate and deep monitoring wells greater than 50 ft bgs.

3.3.3.1 Mud Rotary Drilling

The mud-rotary system consists of a drilling fluid mixture of potable water and bentonite that is pumped down the inside of the drill pipe, and then returned to the surface through the annulus between the drill pipe and the borehole wall. This fluid cools the drill bit, carries the cuttings to the surface, prevents excessive fluid loss into the formation, and prevents the formation from collapsing. The rotating drill pipe turns the bit, which cuts the formation allowing the cuttings to be flushed out. The drilling fluid flows into a mud pit where the cuttings settle out and then is pumped back down the drill rods.

The following steps outline the procedures that will used to drill a deep borehole and install a monitoring well with a mud rotary rig.

1. Record borehole location and intended sample depth intervals (if appropriate) on an ARCADIS Soil Boring/Well Construction Log.

2. The deep boreholes will be drilled from the surface to 1 to 2 ft into the bedrock using a mud rotary drilling rig equipped with a 6-inch bit and stabilizer. No formation sampling will be conducted in the deep boreholes drilled with a mud rotary rig.

3. Record on soil boring/well construction log, any significant or sudden fluid loss or production, and soil cutting observations from drilling mud.

4. The borehole will be terminated to the upper 1 to 2 ft of the bedrock surface, which will be determined by the detection of the bedrock fragments in the return mud.

5. All drill cuttings generated during the deep borehole drilling will be collected and temporarily staged in either 55-gallon steel drums or a roll off box while awaiting characterization and disposal.

3.3.3.2 Rotosonic Drilling

The intermediate and deep monitoring wells will have the option to be drilled using rotosonic drilling methods. The rotosonic drilling method uses a combination of rotary power, hydraulic pull down pressure, and mechanically generated oscillations to advance a dual line of drill pipe. The top mounted hydraulically powered drill head transmits the rotary power, hydraulic down pressure, and vibratory power directly to the dual line of pipe. The inner drill pipe, measuring from 3 to 9-inches, inside diameter, contains a core bit and represents the core barrel sampler. The outer pipe, measuring 4 to 12-inches in diameter, is used to prevent the collapse of the borehole and is therefore used in the construction of monitoring wells from 1 to 8-inches in diameter. This combination of forces advances the inner core barrel sampler through typically difficult unconsolidated deposits and some consolidated formations without the use of mud, or air.

Water is not necessary during drilling but may be used in small quantities to help lubricate the drill pipe as it is advanced. Drilling rates are equal to or greater than other conventional rotary methods when they include some method of continuous sampling.

The inner drill pipe is always advanced in front of the outer drill pipe. Continuous core samples of 1 foot to 20 ft can be completed depending on job specifications and site conditions. Samples range from 3 to 9-inches in diameter.

During typical borehole advancement, the first step is to advance the inner drill pipe and core bit about 6 ft or 10 ft into the ground. Once the inner drill pipe is set, the outer drill pipe is advanced down over the inner drill pipe to hold the boring open. The inner drill pipe is mechanically lifted by the drill head to the surface for core sample recovery. The core sample is vibrated out of the inner drill pipe into a plastic sheath or a stainless steel sample tray. The core sample also can be collected in a split stainless steel or a lexan core barrel liner. The inner drill pipe is then advanced to the next sample interval. These steps are repeated until the desired depth is reached. Installation of the well would be inside the outer drill pipe, which would be removed as the well materials are installed. This will keep the borehole walls from collapsing and ensure that a good sand pack is maintained. Deep monitoring well construction details are discussed in Section 3.3.3.3 below.

The use of water during drilling may be necessary during this drilling program because the drilling will be performed in glacial and alluvial sediments that may be prone to flowing sands. In glacially derived terrain and alluvial sediments, variability of soil conditions among locations is common. Although unlikely at shallower depths, if lithostatic pressure exceeds hydrostatic pressure, flowing sand could result. If the use of water becomes necessary during drilling, clean potable water will be used from the facility's water distribution system. This same water will be used to install the sand pack and for mixing grout. The site geologist will record the volume of water used. If water is used during the drilling of any of the monitoring wells, five times the amount used will be removed during the development of the permanent wells. Information regarding the source of water used and any impact on analytical results will be included in the reports prepared for the site.

All drilling and sampling equipment will be decontaminated according to the procedures outlined in Section 3.8 of this report between each borehole location.

3.3.3.3 Deep Monitoring Well Construction

Casing (riser pipe), screen, and gravel pack will be installed in the open hole for rotary techniques and within the outer casing for the rotosonic technique.

1. The well will be constructed with 4-inch threaded flush joint, or 80 PVC casing with centralizers and 4-inch threaded flush joint, Schedule 80 PVC, 0.010-inch

continuously mill-slotted screen. Schedule 40 pipe will be used in place of Schedule 80 pipe for wells less than 100 ft deep. Centralizers will be used to ensure that the screen is placed in the center of the boring, and that the sand pack is placed evenly around all sides of the screen via a tremie pipe. Pipe joint compound (glue) will not be used in constructing the monitoring wells.

2. Casing will be added to the well and brought from the top of the screened interval to a height of 3 ft above ground level for completion. In high traffic areas and in building interiors, flush-mounted well completions will be used.

3. The annular space between the well and the borehole wall will be backfilled with a clean, graded, size 20 to 40 silica sand pack that will extend from the bottom of the borehole to a minimum of 2 ft above the top of the screened interval. The sand pack will be placed by tremie pipe from the bottom of the borehole to ensure complete placement around the well screen.

4. Approximately 1-ft of very fine sand may be placed above the filter pack to prevent the migration of the bentonite slurry into the well screen.

5. A minimum thickness of 2-ft of bentonite pellets or chips will be placed on top of the filter pack as a seal. If the seal is within the unsaturated zone at the time of installation, the bentonite will be saturated with potable water and allowed to hydrate. Hydration time will conform to the manufacturer's recommendations before further work on the well is performed. If the well is being set within flowing sands and a layer of very fine sand was installed, a 5-ft thick layer of bentonite slurry mixed thicker (using less water) than manufacturers specifications may be installed in place of the bentonite chips to ensure a seal is installed between the filter pack and the grout.

6. The annular space from the top of the bentonite seal to within 1 foot beneath the frost line will be filled with a cement and bentonite slurry containing high solids mixed to the manufacturer's specifications. The bentonite slurry will be placed with a tremie pipe from the bottom of the annular area to be grouted to ensure proper placement of the slurry.

7. The remaining annular space near land surface will be filled with concrete. Wells will be completed as either flush grade or above grade using a protective steel cover. The apron will be a minimum of 2-ft by 2-ft and 4-inches in thickness, and shall be sloped to promote drainage away from the well. The wells also will be equipped with locking caps.

8. At selected above grade completion locations, steel guard posts or protective barriers will be installed around the well in a manner designed to prevent vehicles from accidentally damaging the well.

3.3.4 Monitoring Well Development

The monitoring wells will be developed after a minimum waiting period of 24 hours following the completion of well installation. Development will consist of purging the well until five borehole volumes (well casing and filter pack volumes) of water are removed or until the well produces sediment-free water. The development procedures are described below:

1. Static water level measurements will be collected using the procedures in Section 3.4.2 to determine the volume of the well casing and filter pack.

2. A Grundfos pump or equivalent will be used to develop the new wells. The pump will be set at the midpoint of the screened interval to reduce the sediment uptake by the pump.

3. Begin over-pumping and surging the well in an effort to remove fines. If fines persist, a surge block may be vigorously moved up or down the screen to further develop the well.

4. Resume pumping and surging to remove any additional fine-grained material.

5. Pumping will continue until a minimal amount of fine-grained sediment is present in the well and the following criteria are met at the beginning of the pumping cycle:

   - Five borehole (well casing and filter pack) volumes of water have been removed;

   - The field parameters (pH, temperature, dissolved oxygen, and specific conductance) stabilize to within +/- 10 percent for three consecutive meter readings taken at least 3 minutes apart; and

   - The measured turbidity is less than 50 nephelometric turbidity units (NTUs).

If the field parameters do not stabilize within 5 borehole volumes, development will continue until field parameter stabilization is achieved or 5 to 10 borehole volumes are removed. The amount of water introduced into the well while drilling will be carefully monitored, and at a minimum, a similar amount removed.

The following equation can be used to determine the well borehole volume of standing water:

$$\mathbf{V = 7.48\ [\pi\ r_1^2h_1 + 0.25(\pi r_2^2h^2 - \pi r_1^2h_2)]}$$

where, V = Volume of standing water (gallons)

7.48 = gallons per ft^3

π (pi) = 3.14

r_1 = Radius of well casing/screen (ft)

h_1 = Height of standing water (ft), total depth minus depth to water (ft)

r_2 = Radius of borehole (ft)

h_2 = Total depth minus depth to top of filter pack (ft)

0.25 = Assumed porosity of filter pack

3.4 Groundwater Sampling From Monitoring Wells

Groundwater sampling at the monitoring wells may be completed by purging and sampling the wells using a Grundfos Redi-Flo pump or equivalent, a bailer, or by using low-flow sampling techniques.

3.4.1 Initial Documentation

Observations made prior to actual groundwater sample collection will include a description of the area surrounding the well, whether or not the lock was secure (if applicable), whether the well could have been impacted by surface water run-off, ambient weather conditions and other factors which could affect the final data analysis. This documentation will be recorded on the ARCADIS Groundwater Sampling Form and in the ARCADIS representative's Daily Log (Appendix A).

3.4.2 Fluid-Level Gauging and Water Column Analysis

Prior to groundwater purging and sampling, static fluid levels in each monitoring well will be gauged using a product/water interface probe. Fluid-level measurements, including any potential non-aqueous phase liquids (NAPL) will be documented on ARCADIS Well

Gauging Logs. This task is usually completed immediately after opening the well and following the initial documentation task.

The following procedures will be implemented when collecting well measurements and performing well purging prior to sample collection:

1. Unlock the metal protective casing, remove the well cap, and document the general condition of the well.

2. Measure static fluid-level elevation using an oil/water interface probe from fixed reference point (generally the north side of the top of the PVC casing).

3. The measurements will be repeated until two consecutive measurements are obtained that are within 0.01-ft.

4. Determine the total depth of the well.

5. Calculate the volume of water in the well casing using the formula outlined below.

$$\mathbf{V = 7.48\, \pi\, r^2 h}$$

where, V = Volume of standing water (gallons)

7.48 = gallons per ft^3

π (pi) = 3.14

r = Radius of well casing (ft)

h = Height of standing water (ft), total depth minus depth to water.

Fluid-level measurements will be referenced to a surveyed elevation point located on the top of the well casing. All fluid-level measurements will be taken at least two times to check the reproducibility of the measurement data. If it is found that the measurement cannot be reproduced, a second set of data will be collected. Fluid levels will be collected until the data can be reproduced. This measurement validation process ensures the accuracy of the fluid-level data.

Equipment used to characterize both the fluid level and the water column will be properly decontaminated before each use and between each well using the procedures described in Section 3.8.

3.4.3 Well Purging

The goal of well purging or evacuation is to ensure that the water extracted from the well at the time of sampling is representative of actual groundwater conditions. Thus, it is necessary that all monitoring wells be purged of standing water prior to sampling. The following well purging procedures will be used.

3.4.3.1 Bailer or Conventional Pumping Method

1. Put on clean latex or vinyl surgical gloves or nitrile gloves.

2. A new disposable bailer or Grundfos Redi-Flo pump or equivalent will be used to purge the monitoring wells. The pump will be set at the upper 20-ft of the water column (i.e. not within the screened interval) to effectively evacuate the well. Purging will continue until the following criteria are met:

   - Three to five well casing volumes of water have been removed;

   - The field parameters (pH, temperature, dissolved oxygen, and specific conductance) stabilize to within +/- 10 percent of three consecutive meter readings taken at least 3 minutes apart; and

   - The measured turbidity is less than 50 NTUs, unless low recovery precludes the ability to achieve 50 NTUs.

3. If the field parameters do not stabilize within 3 to 5 well casing volumes, purging will continue until field parameter stabilization is achieved. The equations used to calculate well casing and well borehole volumes are presented in Sections 3.3.4.

4. All equipment used for well purging (evacuation) purposes will be properly decontaminated prior to each use.

3.4.3.2 Low-Flow Purging (Dedicated or Non-Dedicated Pump)

1. Put on clean latex or vinyl surgical gloves or nitrile gloves.

2. The total well depth should not be measured until after the samples have been collected to prevent suspension of possible sediment at the bottom of the well.

3. Compute the volume of water in the well (0.162 gallons/foot for a 2-inch diameter well).

4. For non-dedicated pump, insert the pre-cleaned centrifugal or bladder pump and/or tubing attached to a peristaltic pump into the well to the midpoint of the well screen. For a dedicated pump, connect controller to dedicated downhole bladder pump. Record installation time in field notes.

5. Start pump at the lowest possible flow rate and adjust the pumping rate to approximately 100 milliliters per minute (ml/min). Record pump start time in field notes. Verify the flow rate with the graduated cylinder or equivalent by collecting the water from the discharge line for one minute. Record results in field notes.

6. Monitor water level to verify that little or no drawdown (0 to 0.3 ft) is occurring in the well. If desired, the flow rate may be increased to up to 300 ml/min in more permeable formations as long as minimal drawdown is observed in the well. Record measurements and flow rates in field notes.

7. Obtain field parameter measurements (temperature, specific conductance, pH, dissolved oxygen, oxidation-reduction potential [ORP], and turbidity) after each volume of water is purged and record on the Groundwater Sampling Form. Purging will continue until the criteria listed below have been met (unless low well recovery precludes this):

   - The field parameters (ph, conductivity, and temperature) stabilize to within +/- 10 percent for three consecutive meter readings taken at least 3 minutes apart.

   - The measured turbidity is less than 50 NTUs, unless low recovery precludes the ability to achieve 50 NTUs.

3.4.4 Groundwater Sample Collection

Groundwater samples will be collected using a bailer after the well has been purged by bailing or by using a Grundfos Redi-Flo pump or equivalent, or by using low flow sampling techniques. One of the following sampling procedures will be used at all monitoring well locations:

3.4.4.1 Bailer or Conventional Pumping Method

Groundwater samples will be collected using the bailer used to purge the well or with a new disposable bailer after purging the well with a pump.

1. Put on new surgical gloves;

2. Prepare sample containers;

3. Gently lower the bailer to the screened interval of the well;

4. Gently but quickly retrieve the bailer from the well;

5. Gently pour the contents of the bailer into the sample containers starting with VOCs, taking care to minimize agitation, turbulence and exposure to air. VOCs will be collected and stored first, then SVOCs, pesticides/herbicides, metals, and other parameters will be collected.

6. Secure sample container lid, label, and place samples on ice immediately;

7. Perform final field measurements of temperature, pH, specific conductance, and turbidity on the remaining well fluids.

8. Complete sampling documentation on the ARCADIS Groundwater Sampling Form.

9. Replace cap on well and lock protective casing.

3.4.4.2 Low-Flow Sampling (Dedicated or Non-Dedicated Pump)

1. Collect VOC sample, if required, at low flow rate (100 ml/min) for laboratory analysis directly into the pre-prepared appropriate sample container (Table 1). Ensure that no air bubbles are present in the vial. Secure sample container lid and store sample containers in chilled cooler after filling out the sample label. Proceed with collection of additional samples (i.e., collecting in the order of SVOCs, metals, and other parameters) at low flow rate (100 ml/min) by repeating Steps 1 through 9 above. Secure sample container lids and store sample containers in chilled cooler.

2. Complete sampling documentation on the Groundwater Sampling Form.

3. If inadequate water is present in the well to fill the required sample containers, the sample crew will return periodically within 24 hours until adequate sample volume is obtained and field parameters measured. Groundwater will be collected for individual analyses in the appropriate sample order. VOCs will be collected and stored first, then SVOCs, pesticides/herbicides, metals, and other parameters will be collected.

4. Obtain a final set of field parameter measurements.

5. Turn off pump. For non-dedicated pump, remove portable pump and/or tubing from well and decontaminate or dispose. For dedicated pump, disconnect controller from dedicated pump.

6. Determine the total depth of the well. Compare the measurement of the total depth of the well with previous measurements and well construction log to determine available screen length. Record in Groundwater Sampling Form. If more than 20 percent of a well screen is occluded by sediment, the well must be redeveloped prior to collecting future groundwater quality samples.

7. Replace cap on well and protective casing, lock well.

3.4.5 Groundwater Sample Preservation and Maintenance Procedures

Methods of preservation commonly used are related to pH control, chemical addition, and refrigeration. These preservation methods are used to retard biological degradation, hydrolysis of chemical compounds and complexes, retain original redox conditions, and prevent interaction between the sample and the sample container(s).

Groundwater samples collected for laboratory analysis will be containerized in the appropriate pre-preserved containers provided by the laboratory. All groundwater samples collected during the investigation at the site will be stored immediately on ice at 4°C. In addition to keeping samples chilled, the samples will be promptly transported to the laboratory and analyzed within the appropriate holding times.

3.4.6 Hydraulic Testing

This procedure defines the requirements for conducting a slug test in a monitoring well. An electronic pressure transducer and data logger will be used to measure and record the change in water levels versus time during the slug test.

1. Open the lock, cap, and inspect the wellhead.

2. Measure and record the static water level and the depth to the bottom of the well. Record this data on the Variable Head Test form (Appendix A).

3. Lower the pressure transducer into the well and secure so that the transducer cannot move. Attach transducer to datalogger.

4. Program and start the datalogger. Program the datalogger to record depth vs. time data every second for the first 5 minutes of well recovery, then every 30 seconds for the first 5 minutes, then every minute for the next 50 minutes.

5. Lower the slug into the water until it is fully submerged. Allow the well to equilibrate to static water level.

6. Verify the static water level has been re-established.

7. Withdrawal the slug quickly, but avoid surging. Record the time of withdrawal to hours, minutes, and seconds.

8. Continue recording depth vs. time data for at least one hour or until the well has recovered to at least 90 percent of the static water level. If 90 percent of the static water level has not been achieved within 2 hours, then field personnel may let the data logger record for up to 24 hours.

9. Record the time of test completion in the field data forms.

10. Decontaminate all equipment according to the procedures outlined in Section 3.10.

11. Close and lock the well before leaving.

3.5 Site Survey

The direct-push soil and groundwater borings will be measured to the nearest 1 ft relative to permanent site features. GPS coordinates will be recorded for each soil and groundwater boring, temporary piezometer location, and monitoring well location. GPS coordinates will be used for placement of the sampling locations on the site base map.

A site survey of the temporary piezometers and monitoring wells will be conducted by a registered land surveyor. The survey will consist of establishing an onsite benchmark and surveying all new monitoring wells and temporary piezometer locations using NAD 1983 Missouri (West) State Plane Coordinate system. The measuring point elevation of the installed piezometers and monitoring wells (north side of top of PVC casing) will be surveyed relative to mean sea level to the nearest 0.01 ft. The monitoring wells and piezometers will also be surveyed in the horizontal direction to the nearest 1 ft.

3.6 Field Instrumentation and Analysis

Several instruments will be used to collect field analytical data. These instruments include a PID meter, pH meter, specific conductance meter, a thermometer, and turbidity meter (nephelometer). Field instruments will be calibrated at least once a day, and more often if conditions warrant. Calibration procedures will follow manufacturer's specifications and will be documented by field personnel in a Daily Log (Appendix A).

3.7 Quality Control Samples

To monitor sampling, decontamination, and laboratory performance, it is necessary to collect several types of field Quality Assurance/Quality Control (QA/QC) samples. These field QA/QC samples include trip blanks, equipment rinsate blanks, and field duplicates. The specific number and type of QA/QC samples that will be collected are outlined in the Site Characterization Work Plan.

3.7.1 Trip Blanks

A trip blank is a container filled with distilled and organic-free water prepared in, and provided by, the analytical laboratory. A trip blank is sent from the analytical laboratory to the field sampling site, and is returned to the laboratory for analysis. The trip blank results are used to evaluate whether contamination by VOCs occurred during shipment of samples and/or during container transport. Trip blanks are required in all sample coolers transporting samples for VOC analysis.

3.7.2 Equipment Rinsate

An equipment rinsate blank is a sample of distilled or deionized water, which is exposed to the sampling process to ensure non-dedicated sampling devices have been effectively cleaned. The equipment rinsate blank for the groundwater program will be collected by gently pouring distilled or deionized water over the cleaned pumping equipment or water-level measurement equipment and containerizing the rinsate for laboratory analysis. The equipment rinsate blank for the soil sampling programs will be collected by gently pouring distilled or deionized water over clean core barrels or soil core samplers. Equipment rinsate blanks will be collected at a frequency of 5 percent of the field samples (one per 20 samples) at critical points in the sampling program, such as the sampling of a background well or the end of the sampling program,. The equipment rinsate blank data can be used to detect cross-contamination and determine whether decontamination procedures were adequately followed.

3.7.3 Field Blanks

Field blanks are used to evaluate potential airborne impacts to field samples. In the event that dust or vapors are prevalent during sample collection, a field blank consisting of deionized or distilled water will be poured into clean laboratory supplied sample containers. Field blanks will be collected at a frequency of 5 percent of the field samples (one per 20 samples) during sampling conditions, such as direct push borings or drilling, that indicate dust or vapors could potentially contaminate field samples during collection.

3.7.4 Field Duplicates

A field duplicate sample is a representative aliquot of the same sample, collected in different bottles such that the resulting analytical data can be compared. For example, if a monitoring well is being sampled and a field duplicate sample is required, two sets of sample bottles are prepared. Once the filled sampling device is retrieved, the sample is evenly distributed among all bottles. The bottles are then submitted to the laboratory for analysis under different identifications. A field duplicate will be collected at a frequency of 5 percent of the field samples (one per 20 samples) or one per sampling event, if less than 20 samples.

3.8 Equipment Decontamination

3.8.1 Probing and Drilling Equipment

Any probing and drilling rigs used at the Site will be steam cleaned before any probing or drilling activities are started. The probing and drill rigs will not be decontaminated between boring and/or monitoring well locations. However, all probing and drilling equipment and tools will be decontaminated between each probing or drilling location, and prior to leaving the site.

Cleaning of equipment will be performed using a high pressure cleaner to minimize the potential of cross-contamination. Potable water for cleaning will be obtained from an approved onsite source.

The following procedures will be used for probing and drilling equipment decontamination:

1. Thoroughly steam clean all down hole probing, drilling and well construction tools and materials at a designated decontamination area. This will include, but is not limited to, the drill stem, augers, drill bits, and tools utilized by the contractor.

2. Scrub all down hole tools with a phosphate-free, laboratory grade detergent and potable water mixture.

3. Rinse all scrubbed tools with distilled water.

4. Allow to air dry.

5. All equipment and tools will be isolated from contact with the ground by placing them onto sheets of polyethylene plastic.

A decontamination area will be constructed onsite at a designated area. The decontamination area will include a method to contain decontamination fluids located over plastic sheeting. The generation of decontamination fluids will be minimized to the extent practicable, and the fluids will be collected and stored in polyethylene tanks or 55-gallon steel drums. Characterization and disposal of the decontamination fluids will be handled in accordance with the procedures described in the Investigation Derived Waste (IDW) Plan included in Section 3.9 and in the Waste Management Plan (ARCADIS, 2007). Documentation regarding equipment decontamination will be kept in the ARCADIS representative's Daily Log form.

3.8.2 Field Sampling and Analytical Equipment and Instrumentation

Any equipment used to collect groundwater samples or profile the water column will be decontaminated either using the protocol below or dedicated for one time use. These protocols minimize the possibility of sampling device cross-contamination.

The exterior of sealed, water-tight equipment should be washed with a mild detergent (for example, liquid dishwashing detergent) and rinsed with tap water before storage.

The interior of such equipment may be wiped with a damp cloth if necessary. Other field instrumentation should be wiped with a clean, damp cloth. Conductivity probes, pH meter probes, etc., should be rinsed with deionized water before storage.

For non-dedicated equipment, such as the oil/water interface probe, the following decontamination protocols will be used:

1. Prepare a phosphate-free, laboratory grade detergent, and distilled water mixture in a clean bucket;
2. Put on new surgical gloves;
3. Perform any necessary disassembly;
4. Using a laboratory scrub brush, scrub each piece of equipment with the detergent/distilled water mixture;
5. Rinse the cleaned equipment with distilled water;
6. Allow to air dry on new aluminum foil or plastic sheeting.

3.8.3 Teflon™, Stainless Steel, or Glass Field Sampling Equipment

When Teflon™, stainless steel, or glass sampling equipment is used to collect samples that contain hard to remove materials, it may be necessary to steam clean the field equipment before proceeding with Step 1. If the field equipment cannot be cleaned utilizing these procedures, it should be discarded.

1. Wash equipment thoroughly with laboratory-grade detergent and tap or other approved water (for equipment precleaning, water must be hot), using a plastic brush to remove any particulate matter or surface film.
2. Teflon™, stainless steel, or glass sampling equipment will be rinsed thoroughly with potable water from an approved onsite source.
3. Rinse equipment thoroughly (three times) with deionized water.
4. Wrap equipment completely with aluminum foil or store in Ziploc™ plastic bags to prevent contamination during storage and/or transport to the field.

3.8.4 Ice Chests and Shipping Containers

If the ice chests and reusable containers that will be used to store or ship samples and sample containers are believed to be contaminated, the containers should be washed with laboratory detergent (interior and exterior) and rinsed with portable water and air dried before storage.

3.9 Characterization and Disposal of Investigative Derived Wastes

Investigation-derived wastes (IDW) including soil cores, drill cuttings and mud, decontamination fluids, development water, purge water, product, if any, personal protective equipment (PPE), and other disposable supplies will be characterized and disposed according to the procedures described below and according to the Waste Management Plan (ARCADIS, 2007) developed for the Site.

3.9.1 Soil, Drill Cuttings and Mud

Drill cuttings and drilling mud generated during the investigation and remediation activities at the Site (if any) will be containerized in 55-gallon DOT-approved steel drums or a lined steel roll-off container pending analytical characterization. It is anticipated that soil borings and monitoring wells will be the primary activities potentially generating soil requiring off-site disposal.

3.9.1.1 Characterization of Soil

Drums or roll-off boxes containing drill cuttings, other IDW soils, and drilling mud will be characterized as soon as practicable following generation. The characterization may be completed using generator knowledge and/or existing data or by collecting a representative sample or samples.

Representative samples will be collected in the following manner. A composite soil sample will be collected from each group of 10 drums or individual roll-off box (minimum three aliquots per roll-off box).

All IDW soil samples will be collected according to the procedures outlined in this FSP. Analytical methods, sampling containers, and holding times are presented in Table 1.

3.9.1.2 Disposal of Soil

Based on IDW soil characterization, the IDW soils will either be disposed of off-site at a Subtitle D Landfill as special industrial waste or at a permitted hazardous waste disposal facility in accordance with the Waste Management Plan developed for the Site (ARCADIS 2007) and in compliance with applicable state and federal regulations.

3.9.2 Water

All IDW water produced during the Site activities including decontamination water, well development water, and purge water will be containerized onsite as it is generated. The IDW water will be containerized in 55 gallon DOT-approved drums or polyethylene storage tanks at the Site.

3.9.2.1 Characterization of Water

Water generated during Site characterization activities will be characterized as soon as practicable following generation. The characterization may be completed using generator knowledge and/or existing data or by collecting a representative sample or samples.

3.9.2.2 Disposal of Water

The water will be discharged to the local publically-owned treatment works (POTW) if approval can be secured based on the characterization results. If the water cannot be discharged to the POTW, off-site disposal options will be evaluated and disposal will be completed in accordance with the Waste Management Plan developed for the Site (ARCADIS 2007) and in accordance with applicable state and federal regulations.

3.9.3 NAPL

3.9.3.1 Characterization of NAPL

All non-aqueous phase liquids (NAPL), if any, produced during the Site activities will be containerized onsite as it is generated. The NAPL will be containerized in 55 gallon DOT-approved drums or poly tanks at the Site.

3.9.3.2 Disposal of NAPL

Any NAPL and co-generated water will be disposed off-site in accordance with the Waste Management Plan (ARCADIS 2007) and applicable state and federal regulations.

3.9.4 Personal Protective Equipment and Disposable Supplies

Disposable personal protective equipment (PPE), such as gloves, and sampling equipment, such as disposable bailer and tubing, will be placed in 55-gallon open top steel drums and characterized and disposed in accordance with the Waste Management Plan (ARCADIS 2007) and applicable state and federal regulations.

4.0 Field Documentation

Information on the sample designation, field documentation, chain-of-custody, and sample shipment activities are discussed below.

4.1 Sample Designation

A numbering system will be developed for each type of environmental sample collected during the Site Characterization for the unique identification of each individual sample. This numbering system will provide a tracking procedure to allow ease of data retrieval, reduction, and evaluation, and to ensure that sample identifiers are not duplicated. A listing of the sample identification numbers will be maintained by the project manager and the field task supervisor will ensure that it is universally applied to samples collected during the project.

The numbering system for the Site Characterization consists of the following components described below:

- A two-digit code will be used to designate each of the HPI Sites, as follows:
  - 8S denotes 8th Street Site
  - 4S denotes 4th Street Site
  - 3S denotes 3rd Street Site
  - SY denotes Sylvanie Street Site
- An alpha code will be used to determine sample type or sample origin and shall be designated as:

  SB - Soil Boring Sample from Geoprobe™

  GB - Groundwater Characterization Boring Sample from Geoprobe™

  GT - Geotechnical Soil Sample

  MW - Groundwater Sample from a Monitoring Well

  TPZ – Temporary Piezometer

  IDW - Composite Sample for Disposal Characterization

  EB - Equipment Rinsate Blank

  FB - Field Blank

TB - Trip Blank

- If the sample is a discrete soil or groundwater sample collected from a Geoprobe™ boring, then the depth will be designated in parenthesis after the alpha code.

- If the sample is a soil or geotechnical sample collected from a soil boring in which a monitoring well is to be installed, the well number will be designated following a hyphen.

- If the sample is a soil or groundwater sample collected from a Geoprobe™ boring, the boring number will be designated following a hyphen.

- If the sample is a soil or groundwater sample collected from a Geoprobe™ boring or monitoring well, a QA/Qc samples or IDW sample, an eight-digit date code (YYYYMMDD) will follow the boring or sample number.

- If the sample is a groundwater sample collected from a monitoring well, the well number will be designated following a hyphen.

- If the sample is a groundwater sample collected from a monitoring well that is part of a nested or clustered set, a one-digit alpha code (S, I, or D) designating shallow, intermediate, or deep well will follow the well number.

- If the sample is a QA sample, such as an equipment rinsate blank (EB), trip blank (TB), or field blank (FB), an eight digit date code (YYYYMMDD) will follow the alpha code.

- A two digit numeric code preceded by a hyphen will be used to indicate the sequential QA or IDW sample number for each specific QA or IDW sample type. This code does not apply to soil borings or monitoring wells, as these samples already have a distinct number.

- Duplicates will be assigned unique identifiers similar to the corresponding environmental sample. However, the duplicate identifier will be "blind" to the laboratory, meaning that the lab will not be able to associate the duplicate with the environmental sample.

Examples of the numbering system:

- 8S-SB-14 (8-10) 20071106would indicate a discrete soil sample collected from the Soil Characterization Boring SB-14 at 8 to 10 feet on November 6, 2007 from the 8th Street Site.
- 3S-GB-3 (45-50) 20070122 would indicate a discrete groundwater sample collected from the Groundwater Characterization Boring GB-3 at 45 to 50 feet on January 22, 2007 from the 3rd Street Site.
- 8S-MW-9-20081005 would represent the groundwater sample collected from Monitoring Well MW-9 on October 5, 2008 from the 8th Street Site.
- 4S-TB03-20080603 would represent the third trip blank submitted to the laboratory in a cooler of VOC samples on June 3, 2008 from the 4th Street Site.
- SY-MW-58S-20070518 would represent the blind duplicate of the groundwater sample MW-8S-20070518 collected on May 18, 2007 from the Sylvanie Street Site.

4.2 Field Activity Documentation

Documentation of field operations and sample custody is achieved through use of ARCADIS pre-printed forms. The field log consists of notes and drawings describing the location, field conditions, and method of sample collection and identification.

All aspects of sample collection and handling as well as visual observations shall be documented on the forms. All sample collection equipment (where appropriate), field analytical equipment, and equipment utilized to make physical measurements shall be identified in the field log. All calculations, results, and calibration data for field sampling, field analytical, and field physical measurement equipment shall be recorded in the field log.

All entries in the preprinted sampling logs shall be dated, legible, and contain accurate and inclusive documentation of an individual's project activities. At the end of each day's activity, or of a particular event as appropriate, all documents in the field will be secured by the field manager for each task. Once completed, these preprinted forms will be maintained as part of the project files.

All data forms will be completed in indelible black ink. Make an entry in each blank. Where there is no data entry, enter "UNK" for Unknown or "NA" for Not Applicable. To change an entry, the person making the change will draw a single line through the mistake, add the correct information above or adjacent to it, and initial the change.

4.2.1 Utilities and Structures Checklist

The site manager will check the proposed drilling, sampling, and trenching locations for marked underground utilities, other underground structures and aboveground pipe racks or power lines. A Utilities and Structures Checklist (Appendix A) will be completed by the site manager for each area to be sampled prior to commencement of intrusive field activities.

4.2.2 Location Sketch

All probing drilling, and sampling locations will be drawn on a Location Sketch (Appendix A), if a reasonable site map is not available for the area of interest.

4.2.3 Boring/Well Construction Log

All soil borings, boreholes, and monitoring well installation completed by the field team will be documented in a Boring/Well Construction Log (Appendix A). The log documents the drilling location, drilling dates and times, drilling personnel, logging personnel, soil descriptions, sample depths, recovery, boring location and volatile organic vapor content. The log also documents the well identification, drilling method, development technique, well construction materials, depths, and abandonment, if any.

4.2.4 Water Gauging Log

All water level measurements will be recorded on a Water Gauging Log (Appendix A). The log identifies the measurement location, and measurement date and time.

4.2.5 Groundwater Sampling Form

All groundwater samples collected by the field team will be documented in a Groundwater Sampling Form (Appendix A). The log identifies the sample identification, replicate identification (if any), sampling times, location, equipment used, color, odor, appearance, sample parameters, container description, sample preservative and sampling personnel.

4.2.6 Variable Head Test Log

The data from slug tests completed in monitoring wells during the project will be documented in a Variable Head Test Log (Appendix A). The log identifies the well the slug test is conducted in, the static water level, the initial displacement, and changes in the water level versus time.

4.2.7 Daily Log or Bound Log Book

The Daily Log form (Appendix A) or bound log book is used to record all pertinent sampling events, field observations or other information pertinent to the field effort. The following types of information are generally entered into the Daily Log or bound log book:

- Date
- Client
- Field Location
- Ambient Weather Conditions
- Field Team
- Site Visitors
- Instrument Problems
- Delays
- Unusual Situations
- Well Damage
- Accidents
- Work Progress
- Quality Control
- Site Schedule

4.2.8 Sample Label

All samples collected by the field team will be properly identified by labeling. Labels (Appendix A) will be affixed to the sample bottle prior to the filling of the container(s). Labels are never affixed to lids or caps, although the sample identification information may be duplicated on the cap for ease of sample identification. The following labeling information is supplied for every sample bottle.

- Sample Identification Number
- Initials of Sample Collector
- Date and Time of Collection
- Project Number
- Project Location
- Requested Analyses

4.2.9 Chain-of-Custody Form

The chain-of-custody (COC) form is a multi-copy record, which documents the custody of the samples from sample collection through laboratory analysis. It has spaces for signatures of those receiving and relinquishing the samples. The form is normally signed by the sampler, the individual preparing the samples for shipment, and the receiving individual at the laboratory. An example of this form is included in Appendix A.

The COC forms will be filled out by the field personnel collecting the sample. The COC process will be initiated upon sample collection. The field personnel who sign the form will be responsible for the samples until they are transferred to the custody of the laboratory or another custodian. Once the form has been completed, all remaining field sample identification spaces will be crossed through to prevent unauthorized addition of sample information.

The information required on the COC form includes the complete sample identification, date and time of sample collection, number of sample containers, analyses and method required, container type, project number, sample collection personnel, complete name, address, and telephone number of the person analytical reports will be sent to, turnaround time, and signatures of all sample custodians, excluding shippers, such as Federal Express. In addition, the method of shipment, courier name and airbill number must be included. The back copy of the form will be retained. The original form will accompany the sample shipment to the laboratory.

4.2.10 Chain-of-Custody Seal

All coolers submitted to analytical laboratories containing samples collected during the Site Characterization will be sealed with a COC seal (Appendix A). The seal ensures that the samples have not been tampered with during shipment.

4.2.11 Bill of Lading

A bill of lading, such as a Federal Express airbill, documents receipt of the samples by the carrier. It is not possible for the carrier's representative to sign the COC since it is sealed in the ice chest. Bills of lading are kept on file as part of the sample documentation.

4.3 Chain-of-Custody Procedures

The primary objective of the chain-of-custody process is to create an accurate written record that can be used to trace the possession and handling of the sample from the moment of its collection through analysis. A sample is considered to be in custody when one of the criteria listed below have been satisfied:

- The sample is in one's actual possession.
- The sample is in one's view after being in one's physical possession.
- The sample is in one's physical possession and is then locked up so that no one can tamper with it.
- The sample is kept in a secured area that is restricted to authorized personnel.

Strict COC procedures will be followed for all collection, handling, and shipping of environmental samples. The field personnel are responsible for the care and custody of the samples collected until the samples are properly and formally transferred to another person or a courier for shipment to the laboratory. To simplify the COC record, as few people as possible will handle the sample during the investigation or inspection and an inventory of the sample containers will be maintained.

A COC form will be completed for all samples collected (Appendix A). A separate COC record will be utilized for each cooler of samples shipped to each laboratory used during this investigation. During the data validation activities, it will be determined whether these procedures were adequately followed.

4.3.1 Transfer of Custody

All samples will be accompanied by a COC form. Prior to shipment or transfer of custody, all samples will be maintained in the custody of the field manager. Upon transfer of custody, the field manager will verify the information on each sample label (Appendix A) and assure that each container is intact and sealed. The field manager will then sign and date the COC form. The individuals receiving the samples shall sign, date, and note the time that they reviewed the samples on the COC form. This form documents transfer of custody of samples from the field investigator to another person to the laboratory.

4.3.2 Sample Preparation and Shipment

All samples will be stored at approximately 4°C from immediately after collection until analysis. In the field and during transportation to the laboratory, samples will be kept in coolers on ice. “Blue ice” will not be used. Protective foam or Styrofoam packing will be used to minimize the risk of breakage during transport. When packaging samples for commercial transport, individual bottles will be wrapped separately in padded materials.

The samples are then placed in ice chest with Styrofoam, bubble wrap, or similar packaging to prevent breakage. The ice chest is filled with ice and the original chain-of-custody form and one copy of the form will be placed in a plastic bag secured inside a shipping container closed with a chain-of-custody seal (Appendix A).

4.3.3 Laboratory Sample Receiving

After the ice chests are delivered to the laboratory, the samples are logged in, the COC is signed, and the samples are checked for breakage or leakage. The temperature of the ice bath is checked. If the temperature exceeds 4°C or if any other problems are noted, this information is recorded on the COC and the field task manager or project manager will be notified of the problem.

5.0 References

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APPENDIX A

Appendix A

Field Documentation Forms

ARCADIS

Utilities and Structures Checklist

Project: ______________________ Prepared By: ______________________

Location: ______________________ Date: ______________________

Instructions: This checklist must be completed by an ARCADIS staff member as a safety measure to insure that all underground utility lines, other underground structures, as well as aboveground power lines are clearly marked out in the area selected for boring or excavation. DRILLING OR EXCAVATION WORK MAY NOT PROCEED UNTIL LINES ARE MARKED AND THIS CHECKLIST HAS BEEN COMPLETED. Arrangements for underground utility markouts are best made at the time of the preliminary site visit to allow client and/or utility company sufficient time. Keep completed checklist and maps onsite; send copy to Project Manager.

Assignment of Responsibility: Client is responsible for having underground utilities and structures located and marked. Preferably, the utilities themselves should mark out the lines.

Emergency Procedures: Follow emergency procedures outlined in site-specific Health and Safety Plan.

Utilities and Structures

Type	Not Present	Present	How Marked? (flags, paint, wooden stakes, etc.)
Natural Gas Line			
Electric Power Line			
Telephone Cable			
Sewer Line			
Storm Drain			
Water Line			
Steam Line			
Petroleum Product Lines			
Product Tank			
Septic Tank/Drain Field			
Overhead Power Line			

Name and Affliation of person who marked or cleared underground lines or structures

ORGANIZATION	NAME	PHONE

Comments:

ARCADIS

Location Sketch

Well(s) ____________ Project No. ______________________________ Page ____________ of ____________

Site Location ____

Prepared by ____

(Locate all wells, borings, etc. with reference to three permanent reference points: tape all distances: clearly label all wells, roads, and permanent features)

N

0 ft ft

ARCADIS

Boring/Well Construction Log

JOB NUMBER	CLIENT	LOCATION	WELL NO.	PAGE ____ OF ____	WELL LOCATION
DRILLING METHOD		SAMPLING METHOD			N
DRILLING START FINISH		DEVELOP START FINISH			
STATIC DTW DTO	TIME DATE	DRILLED BY			
ELEVATION TOC GL		LOGGED BY			

WELL CONSTRUCTION	DEPTH FEET	CLASS	NAME	COLOR	DESCRIPTION: GRADATION, SECONDARY CHARACTERISTICS, ODOR, REMARKS.	M.C.	OVA/PID (PPM)	SAMPLE NO.	SAMPLE DEPTH	BLOWS	RECOV %	TYPE
	1											
	2											
	3											
	4											
	5											
	6											
	7											
	8											
	9											
	10											
	11											
	12											
	13											
	14											
	15											
	16											
	17											
	18											
	19											
	20											

ARCADIS

Water Gauging Log

Project No: ______________________ Date: ______________________

Location: ______________________ Recorded By: ______________________

Well Number	Time	Static Depth to Water (ft btoc)	Duplicate Reading (ft btoc)	Total Depth (ft btoc)	Comments

ft btoc Feet below top of casing.

ARCADIS

Groundwater Sampling Form

Project Number: ____________ Task: ____________ **Well ID:** ____________

Date: ____________ Sampled By: ____________

Sampling Time: ____________ Recorded By: ____________

Weather: ____________ Duplicate/QA/QC: ____________

Instrument Identification

Instrument:	PID	Water Quality Meter(s)
Serial #:		

Purging Information

Casing Material: ____________ Purge Method:(circle one) Submersible Centrifugal Bladder Bailer Peristaltic

Casing Diameter: ____________ Screen Interval: From: ________ To: ________

Total Depth: ____________ Pump Intake Setting: ____________

Depth to Water: ____________ Volumes to be Purged: ____________

Water Column: ____________ Total Volume Purged: ________ ________

Gallons/Foot: ____________ Pump On: ________ Off: ________

Gallons in Well: ____________

Field Parameter Measurements During Purging

Time	Minutes Elapsed	Rate (gpm or ml)	Volume Purged	Depth to Water	pH (SI Units)	Conductivity (µmhos/cm)	Turbidity (NTUs)	Diss. Oxygen	Temp (°C or °F)	ORP (mV)	Comments:

Observations During Sampling

Well Condition: ____________ Purge Water Disposal: ____________

Color: ____________ Turbidity(qualitative): ____________

Odor: ____________ Other (OVA, HNU,etc.): ____________

Constituents Sampled	Container Description From Lab ________ ARCADIS ________	Preservative

ARCADIS

Variable Head Test

Project No: ______________________ Date: ______________________

Location: ______________________ Recorded By: ______________________

Well No: ______________________

Well Depth (ft): ______________ Aquifer Thickness (ft): ______________________

Well Diameter (in): ______________ Filter Packed: YES or NO

Casing Height (ft): ______________ Filter Pack Diameter (in): ______________________

Screen Length (ft): ______________ Filter Pack Length (ft): ______________________

Measurement Point: TOC or DATUM Test Type: SLUG IN or SLUG OUT

Date	Time	Elapsed Time			Depth to Water (ft bmp)	Depth to Product (ft bmp)	Remarks
		Hour	Minutes	Seconds			
		0	0	0			STATIC READING

ft bmp Feet below measuring point.

ARCADIS

Daily Log

Well(s) ____________ Project No. ________________________ Page ____________ of ____________

Site Location ____

Prepared by ____

Date/Time	Description of Activities

SAMPLE LABEL

ARCADIS		SAMPLE I.D.
PROJECT #		DATE
SAMPLE TYPE ☐ Soil/Sediment ☐ Water	COLLECTION MODE ☐ Composite ☐ Grab	TIME
ANALYSIS		
SAMPLER	PRESERVATIVE	

ARCADIS

Laboratory Task Order No./P.O. No. ______

CHAIN-OF-CUSTODY RECORD

Page ____ of ____

Project Number/Name ______

Project Location ______

Laboratory ______

Project Manager ______

Sampler(s)/Affiliation ______

Sample ID/Location	Matrix	Date/Time Sampled	Lab ID	ANALYSIS / METHOD / SIZE							Remarks	Total

Sample Matrix: L = Liquid; S = Solid; A = Air

Total No. of Bottles/ Containers ______

Relinquished by: ______	Organization: ______	Date __/__/__	Time ______	Seal Intact?
Received by: ______	Organization: ______	Date __/__/__	Time ______	Yes No N/A
Relinquished by: ______	Organization: ______	Date __/__/__	Time ______	Seal Intact?
Received by: ______	Organization: ______	Date __/__/__	Time ______	Yes No N/A

Special Instructions/Remarks: ______

Delivery Method: ☐ In Person ☐ Common Carrier ______ SPECIFY ☐ Lab Courier ☐ Other ______ SPECIFY

AG 05-12/01

CHAIN-OF-CUSTODY SEAL